NASA TECHNICAL TRANSLATION NASA TT F-15,222

PSYCHOPHYSIOLOGY. RELATIONSHIPS IN RATS BETWEEN SPEED OF LEARNING AND DURATION OF PARADOXICAL SLEEP DURING THE NYCTHEMERIC CYCLE

Jean Delacour, Odile Houcine and
Jean Brenot

Translation of: "Psychophysiology. Relations chez le Rat entre la rapidite d'un apprentissage et la duree de sommeil paradoxal pendant le cycle nycthemeral," Academie de Sciences, Comptes Rendus, Series D, Vol. 275, 6 December 1972, pp. 2725-2728.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 DECEMBER 1973

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,222	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PSYCHOPHYSIOLOGY. RELATIONSHIPS IN RATS BETWEEN SPEED OF LEARNING AND DURATION OF PARADOXICAL SLEEP DURING THE NYCTHEMERIC CYCLE		5. Report Date DECEMBER 1973
		6. Performing Organization Code
7. Author(s) Jean Delacour, Odile Houcine and Jean Brenot		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Techtran Corporation P.O. Box 729 Glen Burnie, Maryland 21061		11. Contract or Grant No. NASw-2485
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Washington, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Psychophysiologie. Relations chez le Rat entre la rapidite d'un apprentissage et la duree de sommeil paradoxal pendant le cycle nycthemeral," Academie de Sciences, Comptes Rendus, Series D, Vol. 275, 6 December 1972, pp. 2725-2728.

16. Abstract

The relationships between paradoxical sleep and avoidance learning in rats were studied according to a procedure reducing the direct interactions between these two variables. The findings of this study suggested the existence of a relationship between the speed of this learning and the value of the duration of paradoxical sleep/waking period ratio during the nycthemeral cycle.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified-Unlimited

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 7	22. Price 3.00

/

NASA-HQ

NASA TT F-15,222

PSYCHOPHYSIOLOGY. RELATIONSHIPS IN RATS BETWEEN SPEED OF LEARNING AND DURATION OF PARADOXICAL SLEEP DURING THE NYCTHEMERIC CYCLE[1]

Jean Delacour[2], Odile Houcine[2] and Jean Brenot[3]

The hypothesis of a relationship between the so-called "paradoxical" sleep phase and learning phenomena [Newman (1), Feldman (2), Feinberg (3), Bloch (4)] has received some experimental confirmations. In rats, the deprivation of "paradoxical" sleep (SP) slows down acquisition of learning [Stern (5)] or unfavorably affects its retention [Leconte (6)]. Reciprocally, the acquisition of learning can be followed by an increase in the quantity of SP [Lucero (7)]. This date has, nevertheless, a certain degree of ambiguity. On one hand, the deprivation of SP can cause a total behavioral disturbance. On the other hand, the modifications of the quantity of SP consequent to learning can be attributed to factors which are only conditions or concomitants of learning, e.g., electrical shocks repeated in the case of a defensive conditioning, deprivation of food in the case of a conditioning with positive reinforcement, expenditure of energy owing to an intensive training, etc. /2725*

We have therefore studied the relationships between paradoxical sleep and learning according to a procedure avoiding direct interactions between these two variables. Its principle was as follows. First, the percentages of paradoxical sleep, "light" sleep and waking state were determined during the nycthemeral cycle for each rat of a uniform lot under constant conditions. These measurements were then correlated with the performances in a learning stage to which the same rats had been subjected.

Method. We used 22 male rats of the Wistar strain, weighing 270 to 350 g at the beginning of the experiment and coming from a uniform lot. According to the customary techniques used for implanting electrodes, each subject had two pairs of electrodes placed on the dura mater on each side of the median line,

[1]Report made by Albert Fessard at the meeting of 13 November 1972.

[2]Jean Delacour, Odile Houcine, Center for Research in Nervous Physiology Department of Psychophysiology, 4, Avenue Gordon-Bennett, 75016 Paris.

[3]Jean Brenot, Center for Nuclear Research, Department of Protection, Service of Protection of Health, Group for Statistics and Computations, P.O.B. No. 6, 92260 Fontenay-aux-Roses, Hauts-de-Seine.

*Numbers in the margin indicate pagination in the foreign text.

one at the bregma level and the other at the lambda level. A third pair of electrodes allowed recording of the myogram of the muscles of the nape of the neck.

After a period of recovery of less than a week, the subjects were subjected to a first test of spontaneous activity lasting for a period of 30 minutes in an actometer which selectively recorded the locomotor activity. This test took place between 1200 and 1400 hours. The subjects were then placed in a recording room whose mean temperature (24 ± 2°C) was comparable to that of the animal center. The illumination cycle (0800 to 2000 hours) was identical in both rooms. During a period of adjustment amounting to at least 24 hours, each /2726 subject was accustomed to wearing on his head the male part of the microconnector which was connected by wires to the recording apparatus. At the end of this period, the electroencephalogram (EEG) and electromyogram (EMG) of the muscles of the nape of the neck were recorded continuously for at least 48 hours.

Following this, the subject was allowed to readjust for 48 hours at the animal center and subsequently subjected to a second test of spontaneous activity under conditions identical to those of the first test, then to 10 sessions (one daily) of the bilateral version of the Mowrer-Miller test. The parameters of this learning situation were the following: a luminous signal (300 hours) came 5 seconds before an electrical stimulus of 1.0 mA and with a maximum duration of 5 seconds. Each completely automated session took place between 1200 and 1400 hours and induced 30 tests separated by a 30 second fixed interval. The session was conducted in a soundproof cabin in which the acoustic insulation was reinforced by a sound background formed by a white noise 70 db above the human threshold. The programming and recording apparatus was located in an adjoining room from where the subjects could be observed by means of closed-circuit television.

Findings. Five chief variables were considered: 1, the performances in the test of activity (A); 2, the number of electrical shocks received during learning (C); 3 to 5. Respectively the total duration, for 24 hours of paradoxical sleep (SP), "light" sleep (SL) and waking state (E). The measurement unit of these periods was the half-minute and they were expressed in percentage of 24 hours. In the majority of cases, these measurements were based on the data collected the second day of recording. The states of paradoxical sleep, light sleep and waking were identified from conventional EEG and EMG criteria [Michel (8), Gottesman (9)]. We did not take into account the performances of two subjects whose EEG and EMG recordings were poor in quality.

I. Correlations between the five main variables. Table I gives the value of the correlations between the A, C, SP, SL and E variables expressed by the Bravais-Pearson r coefficient.

TABLE I.

	A	C	E	SL	SP
A	1				
C	—0,146	1			
E	—0,265	0,330	1		
SL	0,219	—0,202	—0,934	1	
SP	0,335	—0,242	0,179	—0,513	1

Commas indicate decimal points.

The only significant correlations are those between the duration of paradoxical sleep and that of slow sleep ($r = -0.513$, $p < 0.01$) and between the duration of light sleep and that of the waking state ($r = -0.934$, $p < 0.01$).

II. Correlations between the main variables A and C and combinations made /2727
with variables SL, SP and E. One single significant correlation appears in Table II which is the one connecting the number of shocks received to the duration of paradoxical sleep/duration of waking state ratio ($r = 0.383$, $p <$ < 0.05). Figure 1 shows that the relative weakness of this correlation is essentially owing to the performances of 2 subjects who clearly deviate, on the left of the diagram, from those of the other subjects. For the latter, the correlation reaches the value of -0.546, clearly significant ($p < 0.01$).

TABLE II

	SP + SL	SP/SL	SP/E	SP/SP + SL	E/SL	E/SP + SL	E + SP
A ...	0,264	—0,269	0,140	—0,261	—0,256	—0,272	—0,220
C ...	—0,331	—0,165	—0,383[1]	—0,153	0,280	0,330	0,201

Commas indicate decimal points.

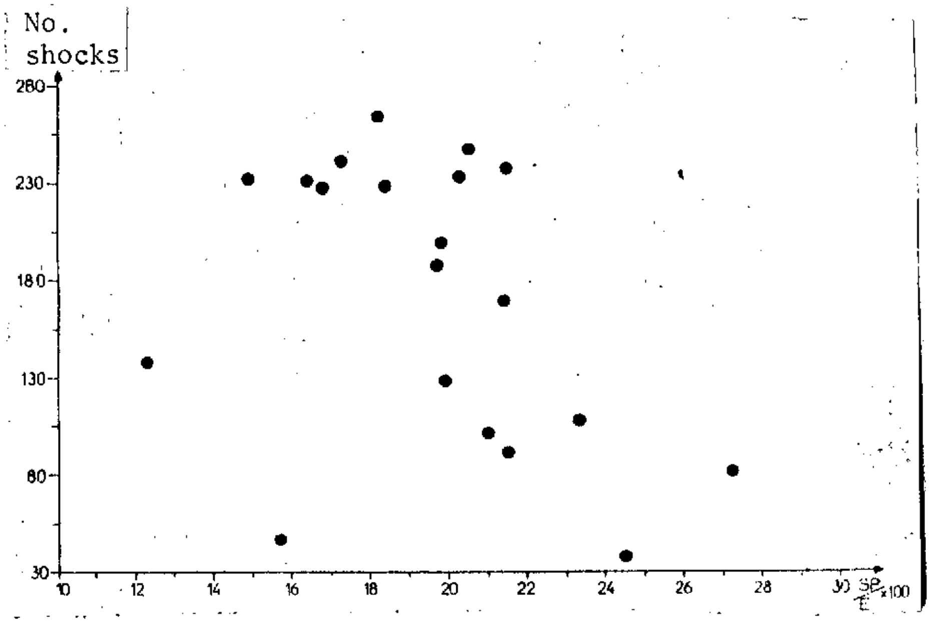

Figure 2. Relationships Between the Duration of Paradoxical Sleep X 100/Duration of Waking State Ratio During the Nycthemeral Cycle and the Number of Shocks Received During Learning of an Avoidance Response.

Discussion. A negative correlation between the C and SP/E variables can be interpreted as the sign of a direct relationship between the speed of learning (inversely proportional to the number of shocks received) and the duration of paradoxical sleep (duration of waking state ratio). It is clear that such a correlation, even moderate, forms a powerful argument for the hypothesis under consideration. Although one of the functions of paradoxical sleep is the consolidation of the data received by the organism during the waking state, this function should be significantly affected by interindividual variations of the SP/E ratio. However, our findings can only provide this interpretation with a limited significance: 1, the variables E, SP and SL /2728 only allow an approximate description of the different states of waking and sleeping which can be characterized beginning from more specific criteria than the ones we have used; 2, even when limited to these three variables, the waking and sleeping states are a function of a number of factors which can, in the same person, modify their relative value as well as making variable their correlation with a learning routine; 3, finally, when these factors are controlled, the complexity of the relationships between the E, SP, SL variables and a learning routine can exceed the capability of elementary statistical techniques. The investigation of the main components of our findings according to the methods of multivaried analysis will perhaps allow a more complete and specific description of these relationships.

REFERENCES

1. Newman, E. and C. Evans, *Nature*, Vol. 206, p. 534, 1965.
2. Feldman, F. and W. Dement, *Psychophysiology*, Vol. 5, p. 203, 1968.
3. Feinberg, I. and E. Evarts, *Biological Psychiatry*, Vol. I, pp. 331-348, 1969.
4. Bloch, V., *Brain Research*, Vol. 24, pp. 561-575, 1970.
5. Stern, W. C., *Psychophysiology*, Vol. 6, p. 224, 1969.
6. Leconte, P. and V. Bloch, *Comptes rendus*, Vol. 271, Series D, pp. 226-229, 1970.
7. Lucero, M., *Brain Research*, Vol. 20, pp. 319-322, 1970.
8. Michel, F., M. Klein, D. Jouvet and J. C. Valaix, *C. R. Soc. Biol.*, Vol. 155, pp. 2389-2392, 1961.
9. Gottesman, C., *Investigation on the Psychophysiology of Sleep in Rats*, Thesis, Paris, 156 pages, 1967.